

Dirt and Sparkle Detection for Film Sequences

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Abstract— Until recently, filming has been an analogue process; it requires a mechanical process to record and view, and the source material itself is prone to decay & abrasion [1]. Film is expensive to store, and prohibitively expensive to restore. All footage - historical, documentary or entertainment - may completely degrade over time. While many archival films stocks are currently being scanned and further damage thus prevented, the digital copies are far from the quality of the original. The types of aberrations found are varied, from frame jitter and line scratches to dirt and sparkle. It is the detection of the latter two (which are frame based abnormalities) that will be examined here.

Keywords— Dirt, sparkle, detection, machine vision, block matching

I. MOTIVATION

Traditionally, when restoring footage, each frame of a motion picture reel must be cleaned carefully by experts, and, for an average feature length of, for example, 2 hours or 7,200 seconds at 24 frames a second, this results in approximately 172,800 frames that have to be cleaned by hand. Aside from the mechanical method of cleaning, particular areas must also be identified, cleaned if *dirt* is present, or 'filled in' if *sparkle* found. Sparkle occurs when the film surface is scratched or scraped away, usually revealing a light surface (silver nitrate) underneath. It manifests as a small white or lightly coloured blotch in a frame of footage, see *Figure 1*.



Fig. 1. Examples of sparkle encircled in the frame above. Note that in the preceding and following frames, sparkle will not be present in the same locations.

Sparkle can occur either chemically, over time, or mechanically, through wear of repeated viewing. Dirt, however, is simply material that has stuck to the frame, as in *Figure 2*.



Fig. 2. Examples of dirt are circled above. Observe no sparkle is present at the points labeled in Fig. 1.

Both are often referred to simply as *blotches*. Given the time consuming nature of restoration, it is extremely expensive & labour intensive. In the digital era, although requiring less in the way of chemicals and physical storage, restoration is very similar to the traditional means. Once the source material has been scanned (usually using a 4K or 8K scanner) the frames are examined individually and dirt & sparkle identified, before being manually removed. The primary advantage may be said to be convenience. Digital automatic detection has been attempted, however.

II. PREVIOUS DIRT AND SPARKLE DETECTION

Industrial software exists (such as AlgoSoft, Amped and DIAMANT) – but the means of detection and success rate are unpublished; however, peer assessment & cinematic critique has not been favourable [2]. Previous academic research includes detection of dirt and sparkle by means of motion estimation and 3D autoregressive modelling – in particular, the JOMBADI (Joint Model Based Detection and Interpolation) algorithm [3]. The JOMBADI approach attempts to combine blotch detection and repair in a single step; a statistical model of the frame is created and motion vectors randomly adjusted until a predicted (reconstructed)

frame is reached (based on either prediction error or maximum number of iterations). This results in either very high computational loads and/or lack of accuracy. Global Motion Segmentation for blotch detection has also been attempted – using this technique, blotches are detected as ‘areas’ of pixels that do not adhere to *any* parametric global interframe transformation model [4]. Being exhaustive, the result is also a computational load, and is subject to the accuracies, inaccuracies and possible contradictions of the various transformation models employed. Czúni *et al* have implemented DIMORF - a neural network for semi automatic detection coupled with an XML database to minimise false positives (by meta tagging incorrect finds in a single frame, all other such instances can be ignored if found in subsequent frames) [5]. As such, DIMORF aspires more as a semi-automatic detection and indexing software system. Regardless of the means, all approaches use pixel intensities as the input data, and most of the systems to date (JOMBADI included) use block matching techniques.

III. BLOCK MATCHING ALGORITHMS

Employed extensively in the domain of video encoding, block matching generally uses motion estimated from the current frame with respect to the previous frame. A motion compensated image is then created from blocks taken from the previous frame. Each frame is divided into ‘macro blocks’, which are then compared with corresponding block and adjacent neighbours in the previous frame. A vector is then created that stipulates the movement of a given macro block from one location to another. The search area (of where the macro block should be located) is constrained by up to p pixels of the previous frame, *see Figure 3*.

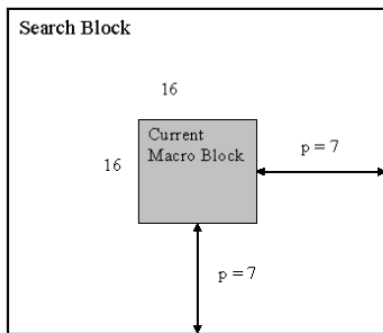


Fig. 3. A sample macroblock search space. The larger p becomes, the more computationally expensive the process is.

Usually the macro block is taken as a square of side 16 pixels, and the search parameter p is 7 pixels. Compression is then achieved by means of JPEG encoded difference images - inherently smaller than the full, original frame [6].

A. Implementation

The work completed to date has consisted of implementing several block matching algorithms, in order to assess their

suitability for potential use in dirt/sparkle detection – previously, only a modified version of the exhaustive search block matching has been used for blotch detection [2]. These algorithms were fully implemented in Matlab, and include exhaustive search, three step search, simple and efficient three step search, new three step search, four step search, diamond search, and adaptive rood pattern search.

B. Results

As an initial means of comparison, each algorithm and their respective number of computations per frame were plotted, *see Figure 4*. In all cases, the macroblock size was set to 16, and the search parameter p was 7, as per the recommended values [7]. Another test was then completed with the presence of an artificial blotch at frame 15. Except for the adaptive rood pattern search, none of the other algorithms’ output changed to reflect the presence of a break or discontinuity in motion estimation for a single frame, as can be seen in *Figure 5*. Adaptive rood pattern search assumes that general motion in a frame is usually coherent, *i.e.*, it attempts to anticipate the direction of the motion vectors; as the others do not use this technique, the amount of computation is unaffected. The adaptive rood pattern search alone was then run on a sample 32 frame sequence, with genuine examples of dirt & sparkle digitally copied and placed at frames 5, 10, 15 and 20. However, the resultant graphs from both runs were identical, as in *Figure 6*. Only when the macroblock size was altered (to 8) and the search parameter p dropped to 4 were useful results obtained, thus indicating that the detection is size and therefore parameter dependent, *see Figure 7*. The encircled plateaus in *Figure 7* that do not exist in *Figure 6* represent the adaptive rood’s attempt to find the closest match; finding such plateaus indicates the location of a potential blotch.

IV. FUTURE WORK

Further analysis and alteration of adaptive rood pattern search is required - in particular macroblock & search parameter size - as well as the potential for implementing detection and eventual reconstruction of the frames via parallel means. Statistical or machine learning classifiers may be applied to suspected blotches to improve classification.

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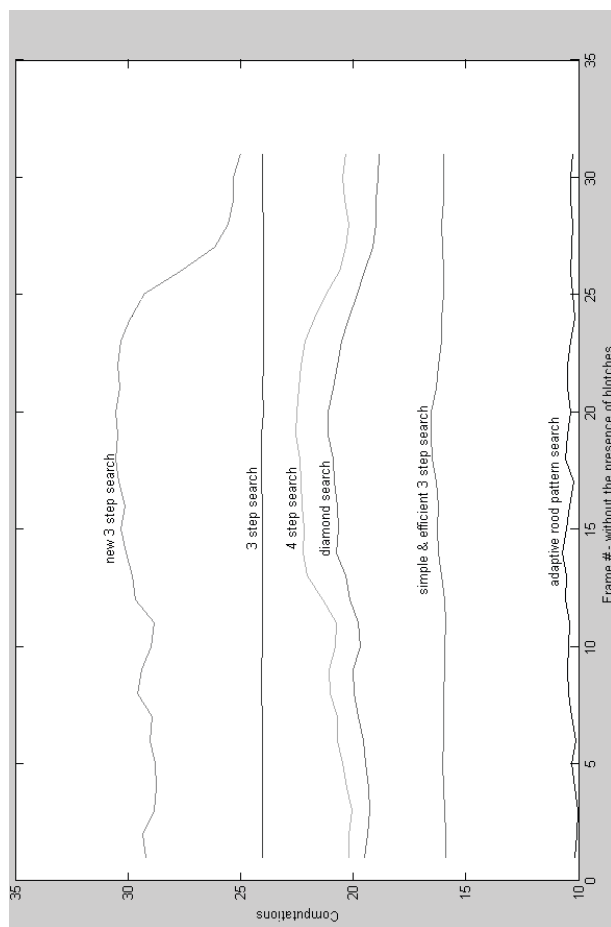


Fig. 4 - A measure of various block matching techniques, compared on the basis of number of computations per frame. The sequence was 32 black and white frames long

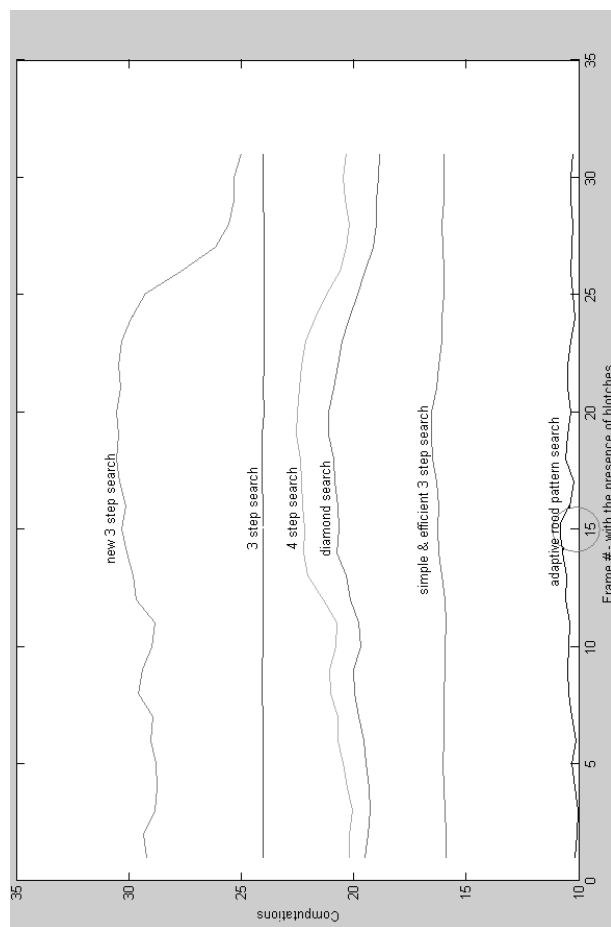


Fig. 5 - Note the change in adaptive rood at the presence of the blotch

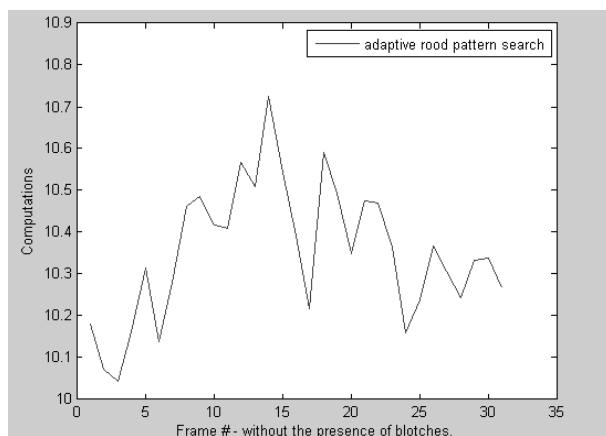


Fig. 6 - 32 frame sequence output, with macroblock and p size altered.

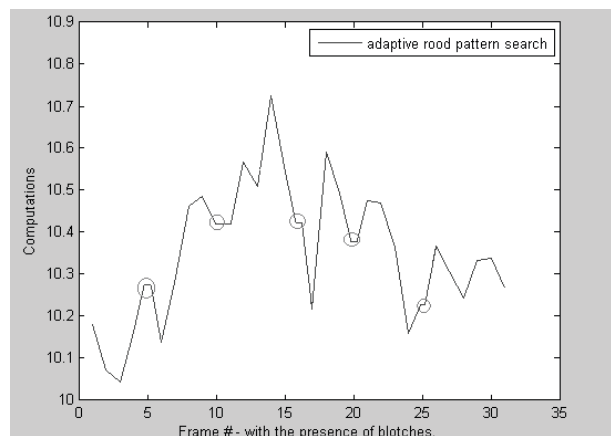


Fig. 7 - 32 frame sequence output, with blotches at the indicated frames